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(54) **Wire bundle sealing system for bulkhead feedthroughs**

Kabelbündelabdichtsystem für eine Schott-Durchführung

Système d'étanchéité d'un faisceau de cables traversant une cloison

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(56) References cited:
DE-C- 3 909 030
GB-A- 2 207 820
US-A- 3 880 453

- **PATENT ABSTRACTS OF JAPAN vol. 096, no. 003, 29 March 1996 & JP 07 296659 A (SUMITOMO WIRING SYST LTD), 10 November 1995,**

Related by irrelevant.

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Description

[0001] The present invention relates to a method and apparatus for sealing separated wire bundles that extend through a multiple passage bulkhead feedthrough.

[0002] The type of bulkhead with which the present invention is concerned is a partition between adjacent compartments for sealing one compartment from another. For example. in airplane construction bulkheads are used to isolate adjacent compartments, such as to permit and maintain pressure differences between the compartments such as wire bundles to pass through the bulkhead. Again using the example of airplane construction, a known rigid "feedthrough" has a large axial bore and is designed to seat in a hole through the bulkhead to form one or more open passages for one or more wire bundles. In the known feedthrough, a divider or "wire separator" is retained in the bore of the feedthrough to define discrete passages for maintaining separation of different bundles.

[0003] The known feedthrough is designed to accommodate a variety of wires and wire bundles. Typically, the bundles are fed through the passages and fit loosely in them. Thereafter, the feedthrough passages must be sealed.

[0004] In the past, the wire bundles were gathered at both sides of the feedthrough, a few inches from it. Plastic tape was used to hold the bundles together. The tape was spiraled around the bundles toward the feedtrough to form a generally conically shaped funnel or mold at each side of the feedthrough. The funnels were then filled with sealant which would flow through the feedthrough and, ideally, provide the desired seal. The system described above used a large quantity of sealant which is expensive and adds to the overall weight of the aircraft. In addition, the gathered bundles may not meet separation requirements. Further, the sealant would not always penetrate between individual wires of each bundle, such that unacceptable leakage could occur lengthwise of a bundle, necessitating reworking of the seal. All in all, the known system was labor intensive in forming the seals, testing the seals and, when necessary, reworking the seals.

[0005] Further US-A-3,880,453 discloses a system for sealing a wire bundle extending through a hole in a bulkhead, comprising a feedthrough to be secured in the hole and having a passage for the wire bundle, and including a tubular segment secured tightly on a stem of said feedthrough, and a quantity of sealant injected into said feedthrough and said passage to seal the wire bundle in said feedthrough.

[0006] This known process for sealing cables and fittings also uses plastic tape to secure a one-sided collar to a stem of said feedthrough, which again is labor-intensive.

[0007] The present invention has for its object to improve upon the above prior art systems and most specifically to obviate the above disadvantages.

[0008] The present invention provides a system for sealing a wire bundle extending through a hole in a bulkhead, comprising a feedthrough to be secured in the hole and having a passage for the wire bundle, and including a tubular segment secured tightly on a stem of said feedthrough, and a quantity of sealant injected into said feedthrough and said passage to seal the wire bundle in said feedthrough characterized by two potting dams each having collar secured tigthly on a respective of said stems, at least one of said dams having a conduit opening into the collar of such dam.

[0009] In the preferred embodiment, a specialized potting dam is secured at opposite sides of the otherwise conventional feedthrough. The potting dam is formed of a soft, pliable, tear-resistant material and has elongated tubular passages or segments aligned with the passages of the feedthrough. Each segment has a continuous peripheral wall for encircling a single wire bundle. The segments are gathered around the bundles close to the feedthrough, such that bundle separation is maintained while sealant is injected through a central conduit of the dam. A minimal amount of sealant is required, and the sealant can be injected under a pressure sufficient to assure that the sealant penetrates the bundles for an effective seal. After the sealant sets, the potting dam can be removed so that is does not add to the weight of the final seal. Preferably, the potting dam is reusable.

[0010] Further the present invention provides a potting dam for a feedthrough secured in a hole of a bulkhead which feedthrough has separate passages for separate wire bundles extending through the passages, said potting dam including a collar adapted to be secured tightly over the feedthrough at one side of the bulkhead and separate tubular segments opening into said collar and positioned to be aligned with the feedthrough passages, each of said tubular segments being adapted to be gathered tightly around a wire bundle, and including a sealant injection conduit opening in the collar of the dam.

[0011] Furthermore the present invention provides a method for sealing wire bundles in a hole in a bulkhead, which method comprises securing a feedthrough feedthrough in the hole which feedthrough has a central passage for the wire bundles, feeding the wire bundles through the passage, securing the collar of a potting dam at each end of the feedthrough, gathering a tubular segment of the potting dam tightly around each of the wire bundles at each side of the feedthrough, and injecting settable sealant into at least one of the potting dams for filling the feedthrough passages and the potting dam collars to seal the wire bundles in the feedthrough.

[0012] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a perspective of a conventional feedthrough, with parts shown in exploded relationship;

FIGURE 2 is a top perspective of the feedthrough of FIGURE 1, with some parts assembled for insertion through a hole in a bulkhead, and a pair of potting dams usable in the wire bundle sealing system in accordance with the present invention;

FIGURE 3 and FIGURE 4 are top perspectives corresponding to FIGURE 2 but with parts in different positions, illustrating sequential steps leading up to formation of a seal by the system of the present invention;

FIGURE 5 is an axial section through component parts of the sealing system in accordance with the present invention, assembled to the condition illustrated in FIGURE 4;

FIGURE 6 is an axial section corresponding to FIGURE 5, illustrating an additional step in formation of a seal by the system of the present invention, namely, injection of sealant;

FIGURE 7 is a front perspective of an alternative potting dam usable in the sealing system of the present invention;

FIGURE 8 is a rear perspective of the potting dam shown in FIGURE 7;

FIGURE 9 is a top perspective of the conventional feedthrough and potting dams of FIGURE 2, but with an additional component, namely, a clamp for securing a potting dam to the feedthrough, with parts shown in exploded relationship;

FIGURE 10 is a top perspective corresponding to FIGURE 9, but with all parts assembled.

Detailed Description of the Preferred Embodiment

[0013] With reference to FIGURE 1, the wire bundle sealing system in accordance with the present invention uses a conventional nylon feedthrough 1 including a cylindrical body formed of two identical semicylindrical halves 2. Such halves meet along an axial plane and form a continuous sidewall. An integral annular flange 3 projects outward from the sidewall approximately midway between the opposite ends of the feedthrough body. The body defines a first cylindrical stem 4 projecting in one direction from the flange and a second cylindrical stem 5 projecting in the opposite direction from the flange. A large central bore extends through the body.

[0014] Prior to securing the two halves 2 together, a divider or wire separator 7a or 7b is inserted in the bore. Separator 7a includes four mutually perpendicular radial partitions 8a to divide the bore through the body into four separate passages. Alternatively, divider 7b is used which includes a diametrical wall 8b and two pairs of aligned walls 8c which are spaced apart lengthwise of wall 8b so as to divide the bore of the body into six separate passages. The selected feedthrough 7a or 7b interfits with the body such that the feedthrough is captured in the body when the two connector halves are joined. For example, the body can have an inward projecting rib 9 at each end which interfits with grooves 10 at the free ends of the partitions 8a, 8b, 8c.

[0015] The assembled body with the selected divider is inserted through a circular hole H of a bulkhead B. Hole H is sized to closely receive the cylindrical stem 5, such that insertion of the body through the hole is limited by engagement of the flange 3 with the bulkhead. In this position, stem 5 projects through the hole and beyond the opposite side of the bulkhead.

[0016] The feedthrough body is held in position by a snap ring 11 which fits in a peripheral groove 12 of stem 5. With reference to FIGURE 1, if required for the particular application, a resilient sealing ring or shim 13 is interposed between the snap ring 11 and the adjacent side of the bulkhead such that there is a tight fit of the feedthrough in the bulkhead.

[0017] FIGURE 3 illustrates the connector 1 secured to the bulkhead B. The wire separator (in this case separator 7a) defines separate passages 6 for wire bundles W. The divider helps to maintain separation between different bundles, which may be required for assuring integrity of signals passed by the wires or to otherwise prevent electrical interference or to assure a desired degree of isolation. When all required wires have been passed through the feedthrough, it is then necessary to seal the wires therein. For example, a settable potting compound can be used, such as a PVC compound, preferably a polysulfide rubber compound. Prior methods for sealing the wire bundles in the feedthrough have used large amounts of the potting compound, and have not always resulted in the desired seal.

[0018] With reference to FIGURE 2, in accordance with the present invention novel potting dams 20 are fitted tightly around the stems 4 and 5 and wire bundles W to define a relatively small, central space for retaining potting compound under a pressure sufficient to assure penetration of the compound into the bundles. Each potting dam 20 includes a base having a cylindrical collar 21 sized to fit snugly over a stem 4 or 5 of the installed feedthrough 1. A small diameter axial conduit 22 opens into the center of the collar. A plurality of integral tubular segments 23 are disposed around the conduit 22. Each segment 23 consists of a peripheral wall that includes a portion exposed at the circumference of the potting dam. Adjacent wall portions of adjacent segments are spaced apart slightly, but the base of each wall is integral with the end of the potting dam having the collar 21. Tubular segments 23 have cross sections corresponding to the cross sections of the passages through the feedthrough.

[0019] Preferably each potting dam is molded in one piece of a soft, pliable, tear-resistant polymer. The two-part polyethylene sold under the trademark Conothane TU-600 is an acceptable material, using a mix ratio of 100 pbw (parts by weight) of Part A and 77 pbw of Part

B. Such material can be cured in the mold for two hours at 80° C, followed by unmolded final curing for 16 hours at 80°C. The resulting part has the required characteristics of being pliable and soft, with a Shore A hardness of about 55 to about 65, preferably about 60, and high tear strength.

[0020] During molding of potting dams 20, a thin but strong end wall 25 is formed between the interior of the collar 21 and the interior of each tubular segment 23. No end wall 26 is formed between the interior of the collar and the interior of the conduit 22. A circumferential reinforcement rib 27 is formed in alignment with the outer or circumferential portions of the segments 23, and radial or cross ribs 28 are formed in alignment with the generally radial portions of the segment walls.

[0021] With reference to FIGURE 3, the potting dams 20 can be installed on the feedthrough 1 after all desired wire bundles W have been passed therethrough. FIGURE 3 illustrates four separate bundles passing, respectively, through the four separate passages 6. However, in a particular application, there may be fewer wire bundles than passages.

[0022] To install the potting dams 20 on a feedthrough 1, a longitudinal slit 30 is cut lengthwise along the circumferential wall portion of each segment 23 for which a wire bundle W extends through the corresponding passage of the feedthrough. The end wall 25 at the base of each such segment 23 is cut away. The potting dam then can be manipulated to a position in which each wire bundle is fitted in a separate segment 23, while unused segments remain closed and unsevered. In general, the base of each segment 23 is of the same cross-sectional size and shape as the corresponding passage 6 through the feedthrough. From its base, the circumferential wall portion of each segment flares outward slightly to assure that the marginal portions adjacent to the slits 30 will overlap and close the slit.

[0023] With reference to FIGURE 4, the collars 21 of the potting dams fit snugly over the corresponding stem of the feedthrough and can be held tightly in place by a conventional ratcheting cable tie or strap 31. The segments 23 through which wire bundles pass are gathered tightly around their wire bundles and are clamped in position by shorter ratcheting cable ties or straps 32, preferably close to the feedthrough. In addition, the conduit 22 of one dam preferably is gathered with one of the segments 23 so that it is closed by the associated strap 32.

[0024] FIGURE 5 shows the positioning of the connected parts. It will be seen that the potting dams 20 define a small, closed core space, with each wire bundle W tightly encircled by the associated soft, pliable tubular segment 23. As illustrated in FIGURE 6, the desired potting compound P then is injected through whichever of the central conduits 22 has not been closed. The potting compound can be injected at a pressure sufficient that it will penetrate between individual wires of each wire bundle and achieve a reliable seal.

[0025] After the potting compound has set, preferably the cable ties 31 and 32 are cut and the potting dams are removed. The material used for the potting dams and the particular potting compound selected preferably permit an easy separation of the potting dams from the potting compound, or a suitable release agent can be used. In either case, the potting dams will be reusable for a feedthrough having the same number of wire bundles or more.

[0026] In the case of a six-way feedthrough (utilizing the divider 7b shown in FIGURE 1), the preferred construction for the potting dams is shown in FIGURES 7 and 8. Six segments 23' are provided, each of approximately the same size and shape as a corresponding passage through the feedthrough 1. Each tubular segment 23' has an exterior wall portion at the circumference of the potting dam 20', to allow a slit to be cut lengthwise for fitting over a wire bundle extending through the associated passage of the feedthrough.

[0027] FIGURES 9 and 10 illustrate a modification using a hinged clamp 40 to secure the potting dam collars 21 to the stems 4 and 5 of the feedthrough connector 1. Each clamp 40 can be opened to the position illustrated in FIGURE 9 or closed to the position illustrated in FIGURE 10. The clamps can be releasably held in the position shown in FIGURE 10 by use of a standard latch and catch mechanism 41. The clamps can have inturned ribs 42 for engaging over the potting dam collars. In addition, the stems of the feedthrough can be provided with additional circumferential grooves 43 toward their outer ends to align with similar inturned ribs 44 of the clamps. FIGURE 10 illustrates a clamp 40 in its closed position holding the potting dam collar 21 over the associated stem. The wire bundles are not shown in FIGURE 10, and typically would have been previously been passed through the feedthrough necessitating cutting of the potting dams for insertion of the wire bundles. Alternatively, the potting dams could be secured to the feedthroughs and be retained in position by the clamps at an early stage of manufacture so that wires could thereafter be fed through the potting dams and feedthroughs prior to gathering the potting dam tubular segments around the wire bundles, securing them in place, and injecting the potting compound through one of the central conduits.

[0028] While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention as defined in the following claims.

Claims

1. A system for sealing a wire bundle (W) extending through a hole (H) in a bulkhead (B), comprising a feedthrough to be secured in the hole and having one or more passages (6) for the wire bundle, and

a quantity of sealant injected into said feedthrough and said passage (6) to seal the wire bundle in said feedthrough **characterized by** two potting dams (20, 20') each having separate tubular segments (23,23') opening into a collar (21) on each potting dam; each collar (21) secured tightly on a respective stems (4, 5), at least one of said dams (20, 20') having a sealant injection conduit (22) opening into the collar of such dam.

2. A system according to claim 1, wherein said feedthrough is provided with separate passages (6) for the respective wire bundles.

3. The system defined in claim 1 or 2, in which the collar (21) and tubular segment (23, 23') of each dam are integral.

4. The system defined in claim 1, 2 or 3, in which the tubular segment (23, 23') is a soft pliant polymer.

5. The system defined in claim 4, in which the soft pliant polymer has a shore A hardness between about 55 and about 65.

6. A potting dam (20, 20') for a feedthrough to be secured in a hole (H) of a bulkhead (B) which feedthrough has separate passages (6) for separate wire bundles (W) extending through the passages, said potting dam including a collar (21) adapted to be secured tightly over the feedthrough at one side of the bulkhead and separate tubular segments (23, 23') opening into said collar and positioned to be aligned with the feedthrough passages (6), each of said tubular segments (23, 23') being adapted to be gathered tightly around a wire bundle, and including a sealant injection conduit (22) opening in the collar (21) of the dam.

7. The dam (20, 20') defined in claim 6, in which each of the tubular segments has an exterior wall portion exposed at the circumference of the potting dam.

8. A method for sealing wire bundles in a hole in a bulkhead, which method comprises securing a feedthrough in the hole which feedthrough has a central passage for the wire bundles, feeding the wire bundles through the passage, securing the collar of a potting dam at each end of the feedthrough, gathering a tubular segment of the potting dam tightly around each of the wire bundles at each side of the feedthrough, and injecting settable sealant through a sealant injection conduit (22) comprised in at least one of the potting dams for filling the feedthrough passages and the potting dam collars to seal the wire bundles in the feedthrough.

Patentansprüch

1. System zum Abdichten eines Drahtbündels (W), das sich durch ein Loch (H) in einer Zwischen- bzw. Querwand (B) erstreckt, umfassend eine Durchführung, die in dem Loch zu befestigen ist und einen oder mehrere Durchgänge (6) für das Drahtbündel hat, sowie eine Menge an Dichtungsmittel, das in die Durchführung und den Durchgang (6) zum Abdichten des Drahtbündels in der Durchführung injiziert wird, **gekennzeichnet** durch zwei Vergußabdämmungen (20, 20'), von denen jede separate rohr- bzw. schlauchförmige Abschnitte (23, 23') hat, die in einen Ring bzw. Bund (21) auf jeder Vergußabdämmung münden, wobei jeder Ring bzw. Bund (21) dicht bzw. straff auf einem jeweiligen Schaft (4, 5) bzw. einer jeweiligen Röhre (4, 5) befestigt ist, wobei wenigstens eine der Abdämmungen (20, 20') einen Abdichtungsmittelinjektionskanal (22) hat, der in den Ring bzw. Bund einer derartigen Abdämmung mündet.

2. System gemäß Anspruch 1, worin die Durchführung mit separaten Durchgängen (6) für die jeweiligen Drahtbündel versehen ist.

3. System nach Anspruch 1 oder 2, worin der Ring bzw. Bund (21) und der rohr- bzw. schlauchförmige Abschnitt (23, 23') von jeder Abdämmung integral sind.

4. System nach Anspruch 1, 2 oder 3, worin der rohr- bzw. schlauchförmige Abschnitt (23, 23') ein weiches biegsames bzw. geschmeidiges Polymer ist.

5. System nach Anspruch 4, worin das weiche biegsame bzw. geschmeidige Polymer eine Shore A Härte zwischen etwa 55 und etwa 65 hat.

6. Vergußabdämmung (20, 20') für eine Durchführung, die in einem Loch (H) einer Zwischen- bzw. Querwand (B) zu befestigen ist, welche Durchführung separate Durchgänge (6) für separate Drahtbündel (W) hat, die sich durch die Durchgänge erstrecken, wobei die Vergußabdämmung einen Ring bzw. Bund (21), der dazu geeignet ist, dicht bzw. straff über der Durchführung auf einer Seite der Zwischen- bzw. Querwand befestigt zu werden, und separate rohr- bzw. schlauchförmige Abschnitte (23, 23'), die in den Ring bzw. Bund münden und so positioniert sind, daß sie mit den Durchführungsdurchgängen (6) abzufluchten sind, umfaßt, wobei jeder der rohr- bzw. schlauchförmigen Abschnitte (23, 23') dazu geeignet ist, dicht bzw. straff um ein Drahtbündel zusammengerafft bzw. -gezogen zu werden, und umfassend einen Dichtungsmittelinjektionskanal (22), der in den Ring bzw. Bund (21) der Abdämmung mündet.

7. Abdämmung (20, 20') nach Anspruch 6, worin jeder der rohr- bzw. schlauchförmigen Abschnitte einen äußeren Wandteil hat, der an dem Umfang der Vergußabdämmung freiliegt.

8. Verfahren zum Abdichten von Drahtbündeln in einem Loch in einer Zwischen- bzw. Querwand, welches Verfahren folgendes umfaßt: Befestigen einer Durchführung in dem Loch, welche Durchführung einen mittigen Durchgang für die Drahtbündel hat, Vorschieben der Drahtbündel durch den Durchgang, Befestigen des Rings bzw. Bunds einer Vergußabdämmung an jedem Ende der Durchführung, Zusammenraffen bzw. -ziehen eines rohr- bzw. schlauchförmigen Abschnitts der Vergußabdämmung dicht bzw. straff um jedes der Drahtbündel auf jeder Seite der Durchführung und Injizieren von härtbarem Dichtungsmittel durch einen Dichtungsmittelinjektionskanal (22), der in wenigstens einer der Vergußabdämmungen enthalten ist, zum Füllen der Durchführungsdurchgänge und der Vergußabdämmungsringe bzw. -bünde für das Abdichten der Drahtbündel in der Durchführung.

Revendications

1. Système de mise en coopération étanche d'un faisceau de fils (W) s'étendant dans un trou (H) formé dans une cloison (B), comprenant une traversée destinée à être fixée dans le trou et ayant un ou plusieurs passages (6) destinés au faisceau de fils, et une quantité d'une matière d'étanchéité injectée dans la traversée et le passage (6) pour assurer l'étanchéité du faisceau de fils dans la traversée, caractérisé par deux barrages à mastic (20, 20') ayant chacun des segments tubulaires séparés (23, 23') débouchant dans un collier (21) sur chaque barrage à mastic, chaque collier (21) étant fixé intimement sur une partie cylindrique respective (4, 5), l'un au moins des barrages à mastic (20, 20') ayant un conduit (22) d'injection de matière d'étanchéité qui débouche dans le collier de ce barrage.

2. Système selon la revendication 1, dans lequel la traversée a des passages séparés (6) destinés à des faisceaux respectifs de fils.

3. Système selon la revendication 1 ou 2, dans lequel le collier (21) et le segment tubulaire (23, 23') de chaque barrage sont solidaires.

4. Système selon la revendication 1, 2 ou 3, dans lequel le segment tubulaire (23, 23') est un polymère souple et tendre.

5. Système selon la revendication 4, dans lequel le polymère souple et tendre a une dureté Shore A comprise entre environ 55 et 65.

6. Barrage à mastic (20, 20') pour traversée destinée à être fixée dans un trou (H) d'une cloison (B), la traversée ayant des passages séparés (6) destinés à des faisceaux séparés de fils (W) s'étendant dans les passages, le barrage à mastic comprenant un collier (21) destiné à être fixé intimement sur la traversée d'un premier côté de la cloison et des segments tubulaires séparés (23, 23') débouchant dans le collier et positionnés afin qu'ils soient alignés sur les passages (6) de la traversée, chacun des segments tubulaires (23, 23') étant destiné à être serré autour d'un faisceau de fils, et comprenant un conduit (22) d'injection de matière d'étanchéité débouchant dans le collier (21) du barrage.

7. Barrage (20, 20') selon la revendication 6, dans lequel chacun des segments tubulaires a une partie de paroi externe exposée à la circonférence du barrage à mastic.

8. Procédé de mise en coopération étanche de faisceaux de fils dans un trou d'une cloison, le procédé comprenant la fixation d'une traversée dans le trou, la traversée ayant un passage central pour les faisceaux de fils, l'avance des faisceaux de fils dans le passage, la fixation du collier d'un barrage à mastic à chaque extrémité de la traversée, le resserrement d'un segment tubulaire du barrage à mastic intimement autour de chacun des faisceaux de fils de chaque côté de la traversée, et l'injection d'une matière d'étanchéité qui peut durcir, par un conduit (22) d'injection de matière d'étanchéité compris dans l'un au moins des barrages à mastic pour le remplissage des passages de la traversée et des colliers des barrages à mastic, afin que les faisceaux de fils coopèrent de manière étanche à l'intérieur de la traversée.

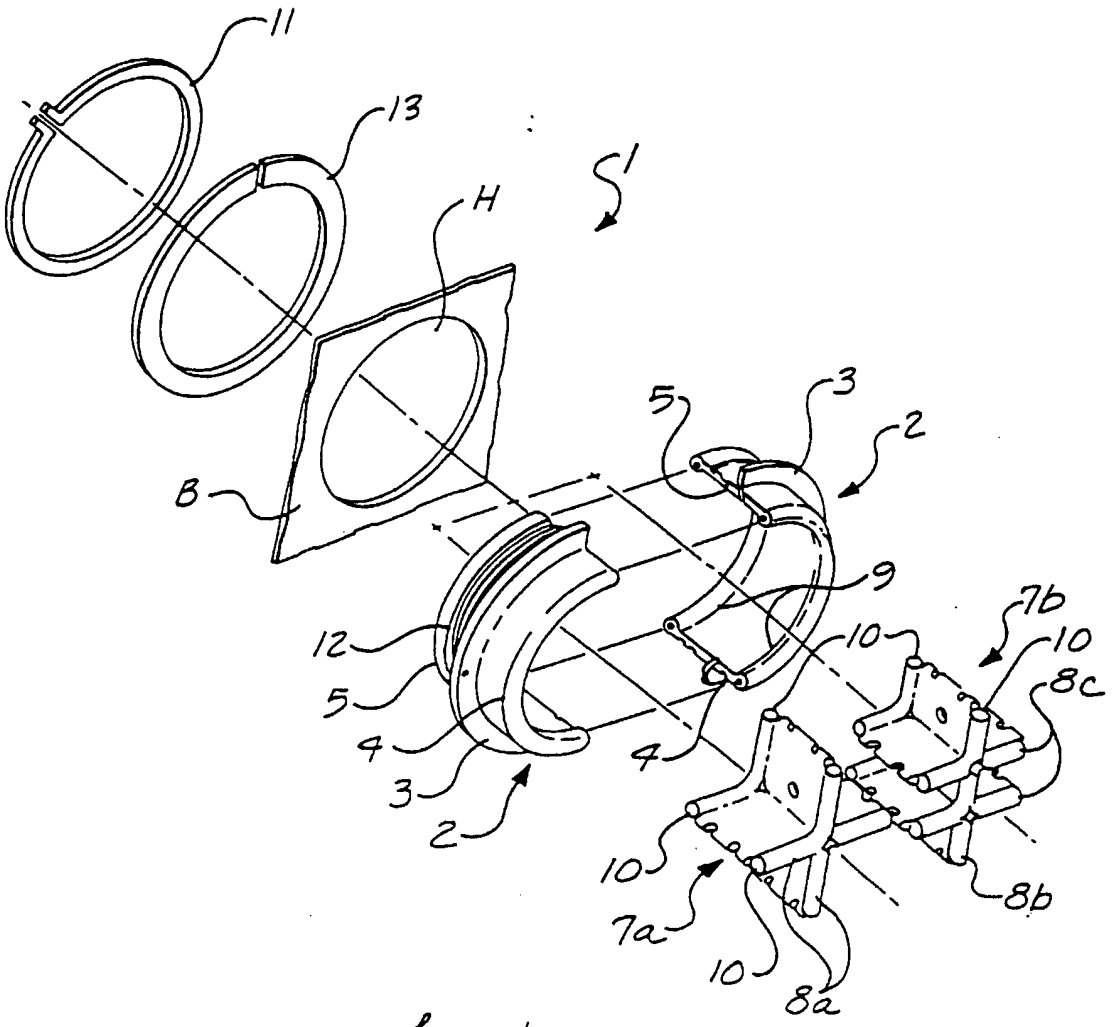

Fig. 1.
PRIOR ART

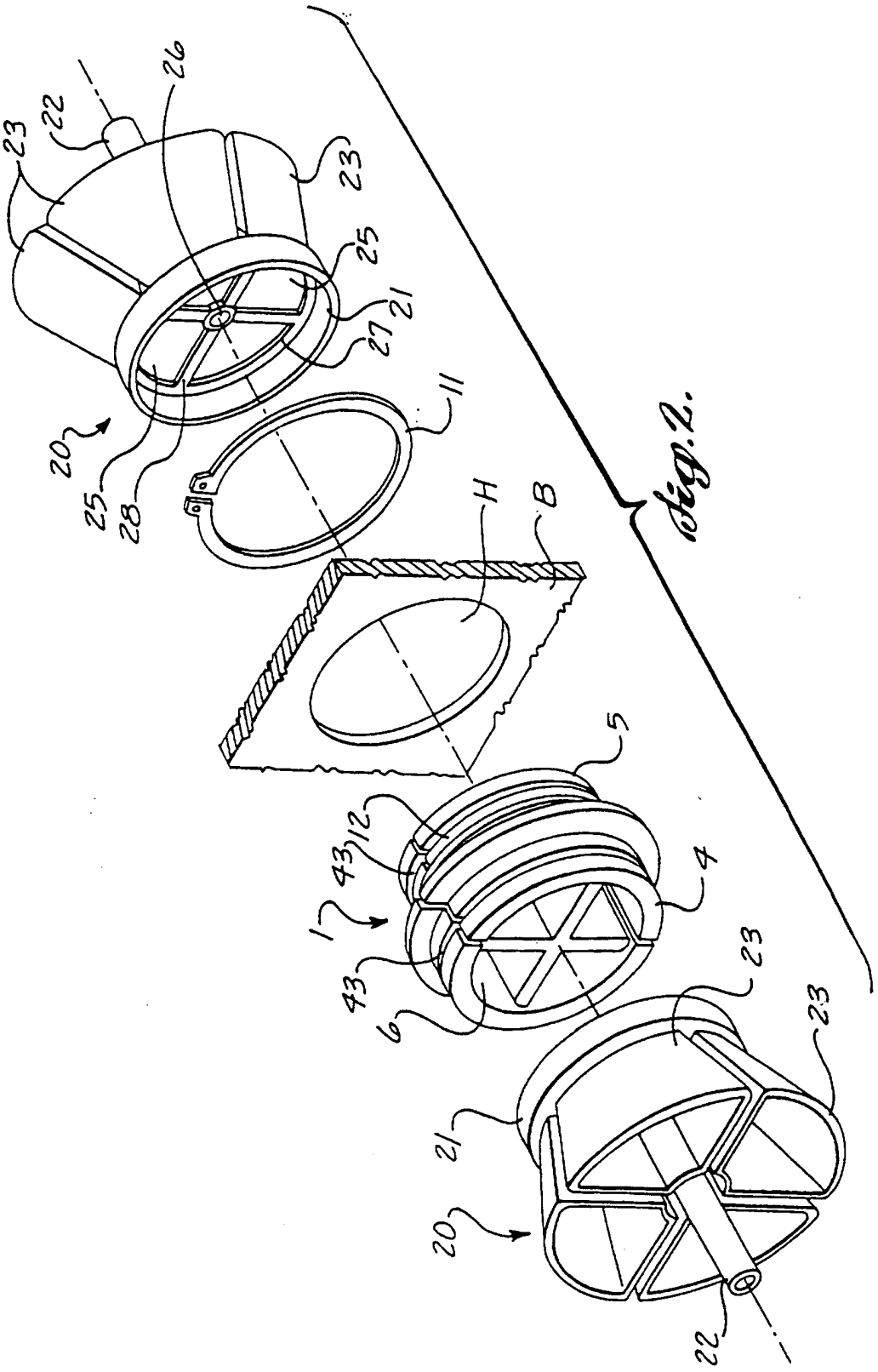

fig.2.

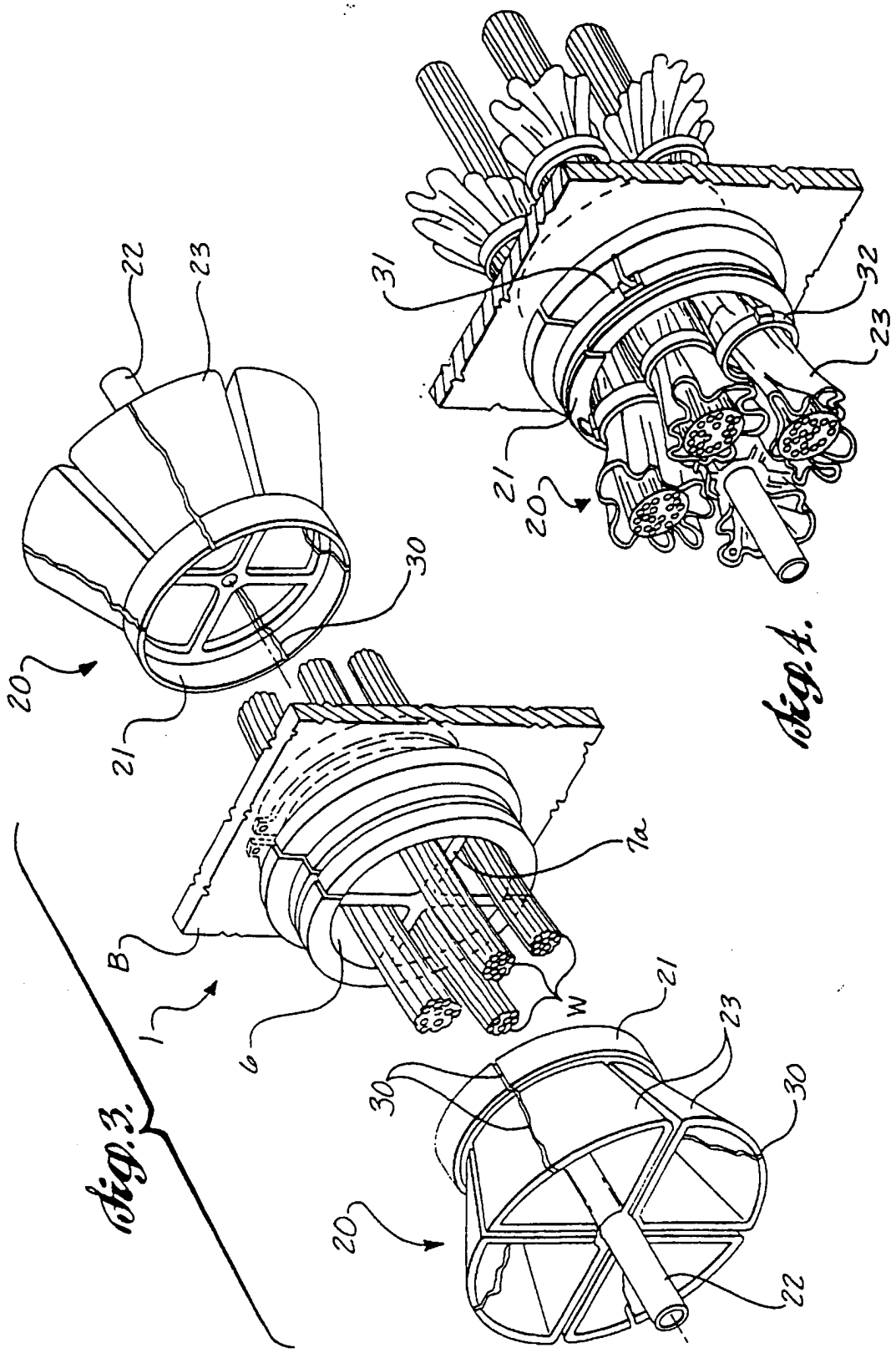

Fig. 3.

Fig. 4.

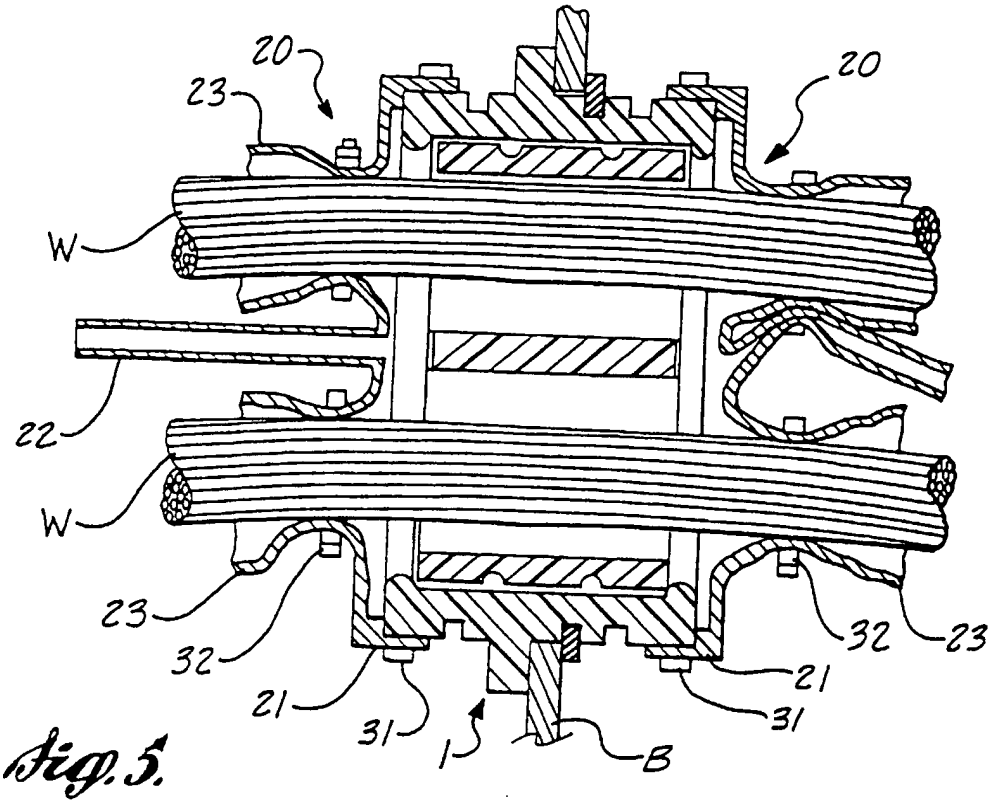

Fig. 5.

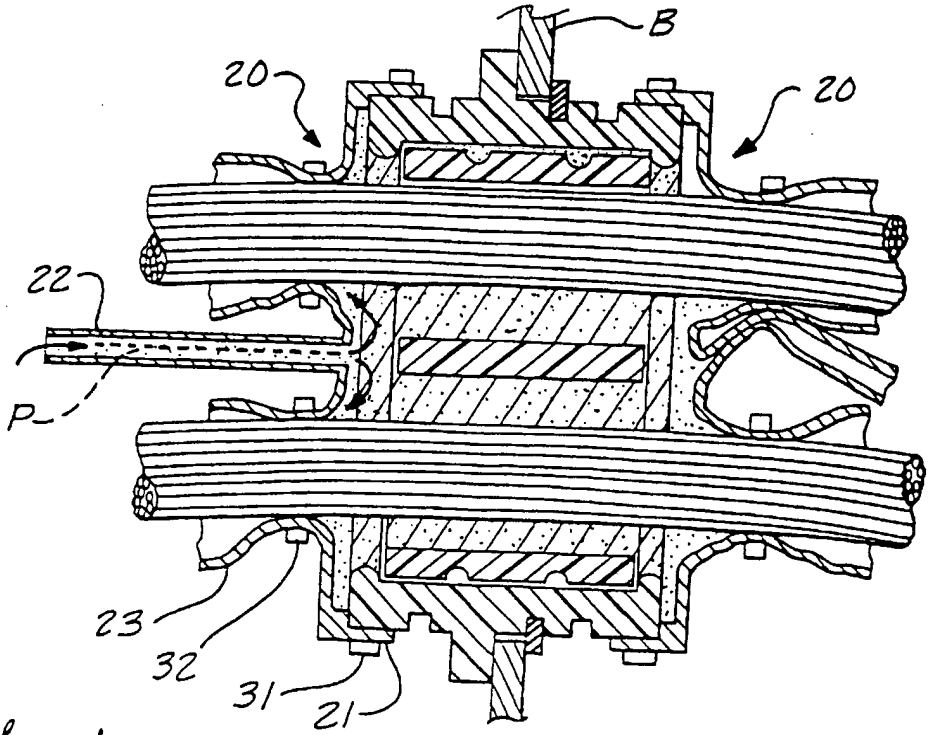

Fig. 6.

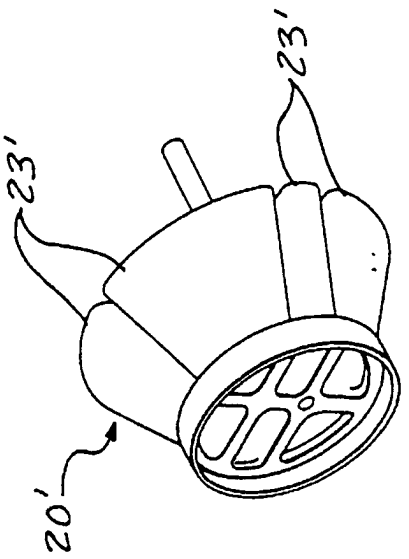

fig.6.

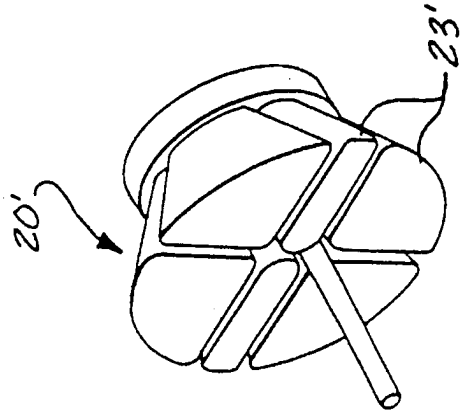

fig.7.

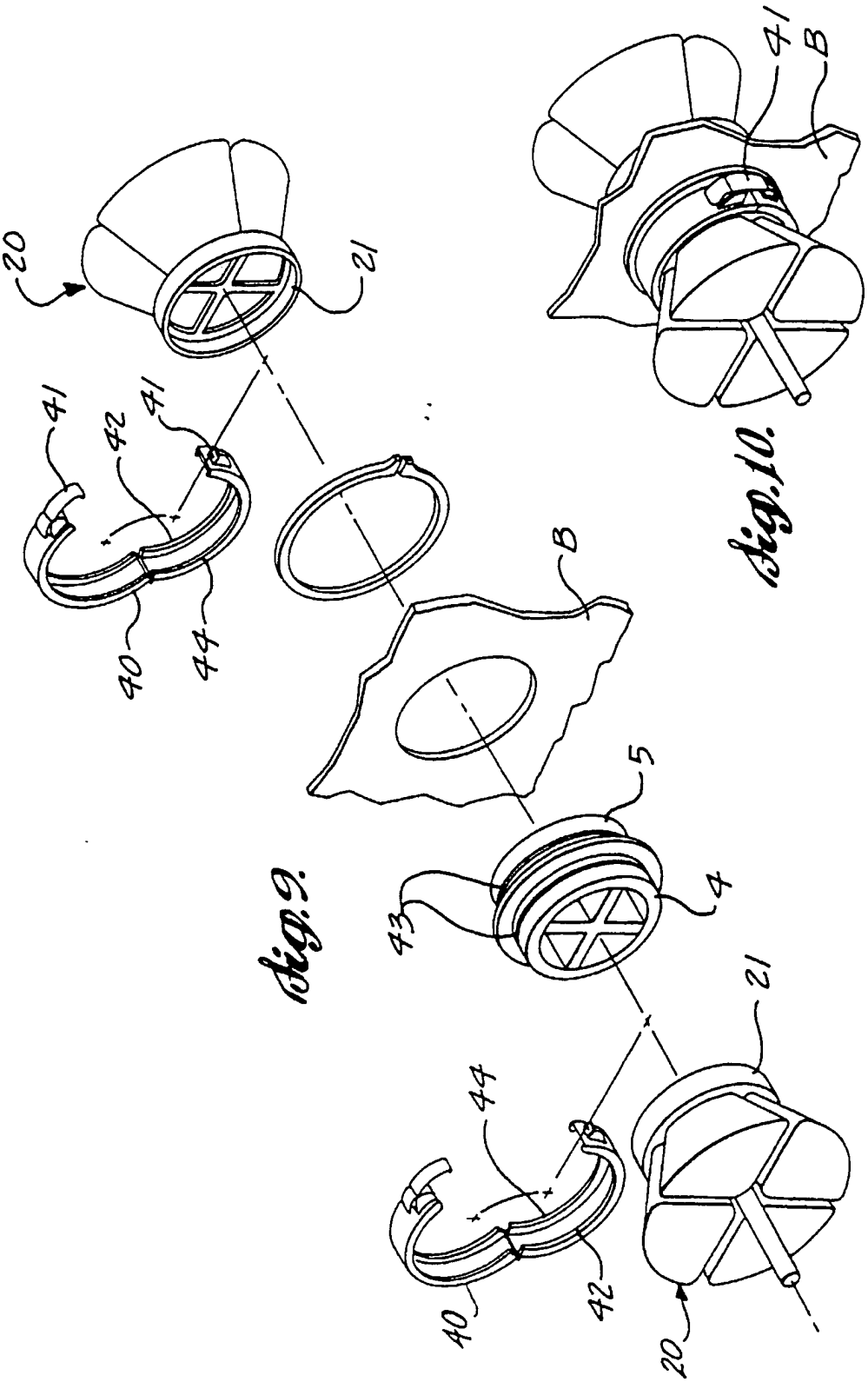

fig.9.

fig.10.